

*SN* > What is claimed is:

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1. A semiconductor optical device apparatus comprising:  
a substrate;  
a compound semiconductor layer containing an active layer;  
5 a protection film having a stripe-shaped opening formed on  
the compound semiconductor layer; and  
a ridge type compound semiconductor layer having a smaller  
refractive index than the refractive index of the active layer,  
the ridge type compound semiconductor layer being formed as to  
10 cover the stripe-shaped opening,  
wherein the compound semiconductor layer, the protection  
film, and the ridge type compound semiconductor layer are formed  
on the substrate, and wherein the semiconductor optical device  
apparatus satisfies either or both of the following conditions
  - 15 (a) and (b):  
condition (a): a width ( $W_c$ ) at an opening center of the  
stripe-shaped opening is different from a width ( $W_f$ ) of the  
opening front end; and  
condition (b): a width ( $W_c$ ) at an opening center of the  
20 stripe-shaped opening is different from a width ( $W_R$ ) of the  
opening rear end.
  2. The semiconductor optical device apparatus according to  
claim 1, wherein the semiconductor optical device apparatus  
satisfies either or both of a condition of  $|W_f - W_c| \geq 0.2 \mu\text{m}$  and  
25 a condition of  $|W_R - W_c| \geq 0.2 \mu\text{m}$ .
  3. The semiconductor optical device apparatus according to  
claim 2, wherein the semiconductor optical device apparatus  
satisfies either or both of a condition of  $|W_f - W_c| \geq 0.5 \mu\text{m}$  and  
a condition of  $|W_R - W_c| \geq 0.5 \mu\text{m}$ .
  - 30 4. The semiconductor optical device apparatus according to  
claim 1, wherein the semiconductor optical device apparatus  
satisfies either or both of a condition of  $|W_f - W_c| \leq 5 \mu\text{m}$  and a  
condition of  $|W_R - W_c| \leq 5 \mu\text{m}$ .
  - 35 5. The semiconductor optical device apparatus according to  
claim 4, wherein the semiconductor optical device apparatus  
satisfies either or both of a condition of  $|W_f - W_c| \leq 3 \mu\text{m}$  and a  
condition of  $|W_R - W_c| \leq 3 \mu\text{m}$ .
  - 40 6. The semiconductor optical device apparatus according to  
claim 5, wherein the semiconductor optical device apparatus  
satisfies either or both of a condition of  $|W_f - W_c| \leq 2 \mu\text{m}$  and a  
condition of  $|W_R - W_c| \leq 2 \mu\text{m}$ .

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7. The semiconductor optical device apparatus according to claim 1, wherein the semiconductor optical device apparatus satisfies a condition of  $W_c \geq 2.2 \mu\text{m}$ .

5 8. The semiconductor optical device apparatus according to claim 1, wherein the semiconductor optical device apparatus satisfies a condition of  $W_c \leq 50 \mu\text{m}$ .

9. The semiconductor optical device apparatus according to claim 1, wherein the semiconductor optical device apparatus satisfies both of the conditions (a) and (b).

10 10. The semiconductor optical device apparatus according to claim 1, wherein the semiconductor optical device apparatus satisfies either or both of  $W_r \geq W_c$  and  $W_R \geq W_c$ .

11. The semiconductor optical device apparatus according to claim 10, wherein the semiconductor optical device apparatus 15 satisfies both of  $W_r \geq W_c$  and  $W_R \geq W_c$ .

12. The semiconductor optical device apparatus according to claim 11, wherein the semiconductor optical device apparatus satisfies a condition of  $W_r = W_R$ .

13. The semiconductor optical device apparatus according to claim 11, wherein the width of the stripe-shaped opening has a portion gradually increasing as coming closing to an opening front end or an opening rear end from an opening center.

14. The semiconductor optical device apparatus according to claim 11, wherein the width of the stripe-shaped opening is approximately unchanged around an opening front end and an opening rear end.

15. The semiconductor optical device apparatus according to claim 11, wherein the semiconductor optical device apparatus satisfies both of  $W_r \geq 3 \mu\text{m}$  and  $W_R \geq 3 \mu\text{m}$ .

30 16. The semiconductor optical device apparatus according to claim 11, wherein the semiconductor optical device apparatus satisfies both of  $W_r \leq 500 \mu\text{m}$  and  $W_R \leq 500 \mu\text{m}$ .

17. The semiconductor optical device apparatus according to claim 11, wherein the semiconductor optical device apparatus 35 satisfies both of  $W_r / W_c \geq 1.2 \mu\text{m}$  and  $W_R / W_c \geq 1.2 \mu\text{m}$ .

18. The semiconductor optical device apparatus according to claim 17, wherein the semiconductor optical device apparatus satisfies both of  $W_r / W_c \geq 1.5 \mu\text{m}$  and  $W_R / W_c \geq 1.5 \mu\text{m}$ .

40 19. The semiconductor optical device apparatus according to claim 11, wherein the semiconductor optical device apparatus satisfies both of  $W_r / W_c \leq 50 \mu\text{m}$  and  $W_R / W_c \leq 50 \mu\text{m}$ .

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20. The semiconductor optical device apparatus according to claim 19, wherein the semiconductor optical device apparatus satisfies both of  $W_F / W_C \leq 10 \mu\text{m}$  and  $W_R / W_C \leq 10 \mu\text{m}$ .

5 21. The semiconductor optical device apparatus according to claim 1, wherein the semiconductor optical device apparatus satisfies either or both of  $W_F \leq W_C$  and  $W_R \leq W_C$ .

22. The semiconductor optical device apparatus according to claim 21, wherein the semiconductor optical device apparatus satisfies both of  $W_F \leq W_C$  and  $W_R \leq W_C$ .

10 23. The semiconductor optical device apparatus according to claim 22, wherein the semiconductor optical device apparatus satisfies a condition of  $W_F = W_R$ .

15 24. The semiconductor optical device apparatus according to claim 22, wherein the width of the stripe-shaped opening has a portion gradually decreasing as coming closing to an opening front end or an opening rear end from an opening center.

20 25. The semiconductor optical device apparatus according to claim 22, wherein the width of the stripe-shaped opening is approximately unchanged around an opening front end and an opening rear end.

26. The semiconductor optical device apparatus according to claim 22, wherein the semiconductor optical device apparatus satisfies both of  $W_F \geq 0.5 \mu\text{m}$  and  $W_R \geq 0.5 \mu\text{m}$ .

25 27. The semiconductor optical device apparatus according to claim 22, wherein the semiconductor optical device apparatus satisfies both of  $W_F \leq 10 \mu\text{m}$  and  $W_R \leq 10 \mu\text{m}$ .

28. The semiconductor optical device apparatus according to claim 22, wherein the semiconductor optical device apparatus satisfies both of  $W_F / W_C \geq 0.02$  and  $W_R / W_C \geq 0.02$ .

30 29. The semiconductor optical device apparatus according to claim 28, wherein the semiconductor optical device apparatus satisfies both of  $W_F / W_C \geq 0.1$  and  $W_R / W_C \geq 0.1$ .

35 30. The semiconductor optical device apparatus according to claim 22, wherein the semiconductor optical device apparatus satisfies both of  $W_F / W_C \leq 0.85$  and  $W_R / W_C \leq 0.85$ .

31. The semiconductor optical device apparatus according to claim 30, wherein the semiconductor optical device apparatus satisfies both of  $W_F / W_C \leq 0.7$  and  $W_R / W_C \leq 0.7$ .

40 32. The semiconductor optical device apparatus according to claim 1, wherein the semiconductor optical device apparatus satisfies either  $W_F \leq W_C \leq W_R$  or  $W_F \geq W_C \geq W_R$ .

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33. The semiconductor optical device apparatus according to claim 32, wherein the semiconductor optical device apparatus satisfies a condition of  $|W_F - W_R| \geq 0.5 \mu\text{m}$ .

5 34. The semiconductor optical device apparatus according to claim 32, wherein the semiconductor optical device apparatus satisfies a condition of  $|W_F - W_R| \leq 100 \mu\text{m}$ .

35. The semiconductor optical device apparatus according to claim 34, wherein the semiconductor optical device apparatus satisfies a condition of  $|W_F - W_R| \leq 50 \mu\text{m}$ .

10 36. The semiconductor optical device apparatus according to claim 32, wherein the semiconductor optical device apparatus satisfies a condition of  $W_F \leq W_C \leq W_R$ .

37. The semiconductor optical device apparatus according to claim 32, wherein the semiconductor optical device apparatus 15 satisfies a condition of  $W_F \geq W_C \geq W_R$ .

38. The semiconductor optical device apparatus according to claim 37, wherein the semiconductor optical device apparatus satisfies a condition of  $W_F / W_R \geq 1.2$ .

20 39. The semiconductor optical device apparatus according to claim 38, wherein the semiconductor optical device apparatus satisfies a condition of  $W_F / W_R \geq 1.5$ .

40. The semiconductor optical device apparatus according to claim 37, wherein the semiconductor optical device apparatus satisfies a condition of  $W_F / W_R \leq 50$ .

25 41. The semiconductor optical device apparatus according to claim 40, wherein the semiconductor optical device apparatus satisfies a condition of  $W_F / W_R \leq 10$ .

42. The semiconductor optical device apparatus according to claim 1, wherein no protection film is formed on a ridge top 30 and a side surface of the ridge type compound semiconductor layer.

43. The semiconductor optical device apparatus according to claim 1, wherein a contact layer is formed to cover a ridge top and a side surface of the ridge type compound semiconductor 35 layer.

44. The semiconductor optical device apparatus according to claim 1, wherein a crystal growth plane of the substrate is (100) plane or its crystallographically equivalent plane, and wherein a longitudinal direction of a stripe-shaped opening of 40 the protection film is [01-1] direction or its crystallographically equivalent direction.

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45. The semiconductor optical device apparatus according to claim 1, wherein the ridge type compound semiconductor layer is formed at a portion on the protection film.

5 46. The semiconductor optical device apparatus according to claim 1, wherein the compound semiconductor layer containing the active layer includes a layer in which an In content of the compound crystal is 5 % or higher, and wherein the In content of the compound crystal of the ridge type compound semiconductor layer is 10 % or less.

10 47. The semiconductor optical device apparatus according to claim 46, wherein the clad layer having a refractive index smaller than that of the active layer formed on the active layer has an In content of 5 % or higher.

15 48. The semiconductor optical device apparatus according to claim 46, wherein at least one layer among the clad layer having a refractive index smaller than that of the active layer formed below the active layer, the active layer, and the clad layer having the refractive index smaller than that of the active layer formed on the active layer is made of a compound represented by  $(Al_xGa_{1-x})_yIn_{1-y}P$  [ $0 \leq x \leq 1$ ,  $0.05 \leq y \leq 1$ ].

20 49. The semiconductor optical device apparatus according to claim 46, wherein the In content of the compound crystal of the ridge type compound semiconductor layer is 5 % or less.

25 50. The semiconductor optical device apparatus according to claim 49, wherein the In content of the compound crystal of the ridge type compound semiconductor layer is 1 % or less.

51. The semiconductor optical device apparatus according to claims 1, wherein the semiconductor optical device apparatus is a semiconductor light-emitting device.

30 52. The semiconductor optical device apparatus according to claim 1, wherein the semiconductor optical device apparatus is a semiconductor laser.

35 53. The semiconductor optical device apparatus according to claim 1, wherein the semiconductor optical device apparatus is a semiconductor optical amplifier.